



PUBLISHED QUARTERLY BY UTAH GEOLOGICAL AND MINERAL SURVEY

# SURVEY NOTES

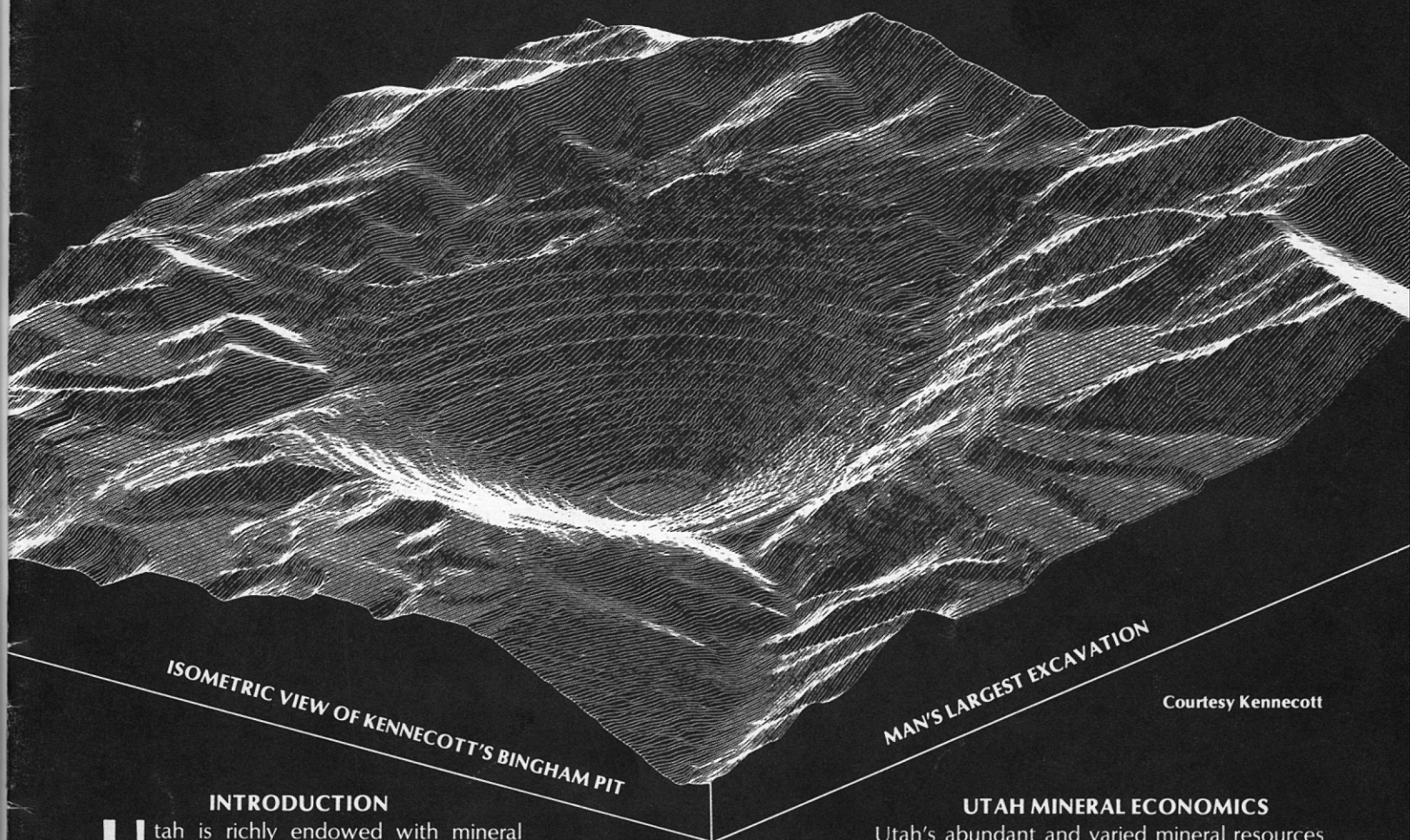
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Spring 1983

## MINERAL RESOURCES OF UTAH

By HELLMUT H. DOELLING



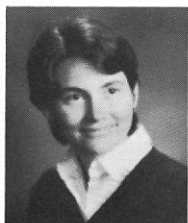
Courtesy Kennecott

### INTRODUCTION

Utah is richly endowed with mineral deposits and in the past their exploitation has been inextricably entwined with the State's economy. As Utah's economy becomes more diversified non-earth scientists and non-mineral economists tend to undervalue the importance of Utah's mineral industries, but it is the mineral industry that provides the raw materials and energy to sustain this diversity.

### UTAH MINERAL ECONOMICS

Utah's abundant and varied mineral resources were exploited over one hundred years ago for the more "glamorous" mineral commodities (precious metals, base metals, precious stones, etc.), followed by the development of energy fuels. In time, as other industries developed, the non-metallic materials (chemicals, salines, construction materials, etc.) became important. Figure 1 shows the percent (see page 4)



## FROM THE DIRECTOR'S DESK

### Utah Geological and Mineral Survey Board

The statute that reorganized the UGMS in 1973 reorganized the existing advisory board into the present UGMS Board and stipulated that

"The board shall be comprised of seven members appointed by the governor, with the advice and consent of the senate. Of the members so appointed, all of whom shall possess the knowledge, skill, and experience to fit them for the position, one shall be knowledgeable in the field of geology as applied to the practice of civil engineering, four shall be representative of various segments of the mineral industry throughout the state, (such as hydrocarbons, solid fuels, metals, and industrial minerals), one shall reflect the economic or scientific interests of the mineral industry in the state, and one, interested in the goals of the Survey, shall be from the public at large... The director of the Division of State Lands shall be an *ex-officio* member of the Board but without any voting privilege."

#### Presently the Board consists of—

**Chairman: Kenneth Poulson** (Brush Wellman, Inc.) representing minerals industry/metals and industrial.

**Vice Chairman: Laurence Lattman** (College of Engineering and Mines, U of U) representing minerals industry/hydrocarbons (oil and gas).

**James H. Gardner** (new member, College of Business, U of U) representing economic/business interests.

**Robert P. Blanc** (new member, Getty Mining) representing mineral industry/metals.

**Jo Brandt** (new member, former legislator) representing public at large.

**E. Peter Matthies** (Sharon Steel) representing mineral industry/solid fuels.

**Elliot Rich** (College of Civil Engineering, USU) representing engineering/geology.

The UGMS Board provides two invaluable services in addition to its general monitoring and advice on the UGMS programs:

1. An outreach into the petroleum, mining, geological, and taxpayers (public) communities and relays feedback to the UGMS director. This information helps the Survey to prioritize programs and evaluate their effectiveness;
2. The Board understands the UGMS programs and can advertise or defend the Survey's role in State government when UGMS programs are under attack or not well understood.

In past years, it has been the Board and its predecessors that have been called upon to "make a save" when the UGMS has been faced with near extinction. That threat has been remarkably frequent: in 1941, 1949, 1951, 1961, and 1972 proposals concerning government reorganization threatened the character and financial support of the Survey. Each time, the geologic community rallied to the Survey's defense. The three members who have recently retired from the Board (Robert Bernick, Benton Boyd, and Natalie Mallinckrodt) were all a part of the transition of the UGMS from the University of Utah to the Utah Department of Natural Resources. That transfer took place when it became apparent that the University budgeting process was not always responsive to the needs of the UGMS. In fact, in 1972, the University of Utah omitted the UGMS from its budget request to the legislature. The legislature got the message and based on input from the geologic community and the assurance of strong Board participation, it transferred the Survey from the University of Utah to the Utah Department of Natural Resources effective 1973.

During the past decade, the UGMS has almost quadrupled in size. Its mission shifted from a reliance on academic studies and resource investigations to resource studies dictated by State needs. The pendulum has swung from a situation where projects were considered relatively academic and primarily meeting the needs of the scientific community to a Survey whose staff spends over three quarters of their time responding to State requests for geologic information. It would be my hope that with the beginning of a basic geologic mapping project (approximately ten quadrangles per year) the UGMS can continue to respond to the State's needs, and at the same time systematically collect the basic geologic information that is invaluable not only for the State's needs but to the understanding of Utah's geology.

The UGMS Board actively protects the Survey from the forces of politics and provides the Survey with invaluable advice on priorities for projects and programs. It is with gratitude that we say goodbye to three of the "old guard" of the Board and it is with anticipation that we look forward to the active participation of the new members.

*Garvine Atwood*



## Meet the Members of the UGMS Board



R. Ollins, DNR Public Affairs

UGMS Board considering rule on confidentiality of certain geologic information. Front row, from left to right: Jo Brandt (Board member), Gail Prince (representing Division of State Lands), Robert P. Blanc (Board member), Lawrence H. Lattman (Vice-Chairman of Board), Kenneth R. Poulson (Chairman of Board). Back row, from left to right: Anne Stirba (Attorney General's Office), Lorin P. Nielsen (Assistant Director, Department of Natural Resources), Jim Grambihler (representing Utah Petroleum Association), Bob Bernick, Jr. (Deseret News).

**Kenneth R. Poulson**, (*Brush Wellman, Inc.*), *Chairman of the UGMS Board.*

Mr. Poulson earned his bachelor's degree in business from the University of Utah. He is a former member of the Board of Governors of the Salt Lake Area Chamber of Commerce, past president of the Utah Mining Association, presently serving on the Executive Committee of the Board of Directors, past chairman of the Utah section of AIME, and a member of the advisory council of the College of Mines, University of Utah.

His career in mining started several years after graduation from the University of Utah and has been associated mainly with development of the beryllium properties in western Utah...bringing them from early stages of exploration and development through final production. He is presently vice president, Mining and Exploration, Beryllium Products Group, Brush Wellman.

**Laurence H. Lattman**, *Dean (College of Engineering and College of Mines and Mineral Industries, University of Utah), Vice Chairman of the UGMS Board.*

Dr. Lattman earned his bachelor's degree in chemical engineering from City College of New York; he earned a master's and a doctorate in geology from the University of Cincinnati. He

was as a field geologist for Gulf Oil Company for five years and was on the faculty of The Pennsylvania State University for 15 years. From 1970-75 he served as chairman of the Department of Geology at the University of Cincinnati. In 1975, he taught at the Soviet Union's Moscow State University under a Fulbright professorship. He came to Utah that September as professor of geology and dean of the College of Mines and Mineral Industries. He was named to the additional responsibility of dean of the College of Engineering in 1978.

He recently accepted the position of president of the New Mexico Institute of Mining and Technology, Socorro, N.M. The UGMS is happy for the New Mexico geological survey's gain but will miss Larry's service on our Board.

**Robert P. Blanc** (*Manager of U.S. Minerals, Exploration and Production, Getty Oil Company*).

Mr. Blanc earned his bachelor's and master's degrees in geology from UCLA. Formerly a geologist with the Richfield Oil Company, Minerals Group, he joined Getty Oil in their newly formed Minerals Group in 1966 and has since served in a variety of capacities. He is presently manager of their U.S. Minerals, Explora-

tion and Production. Mr. Blanc is a member of the SEG and AIME, an officer and member of the Board of the Utah Mining Association, and serves on the advisory council of the College of Mines and Mineral Industries, the University of Utah. He is also a member of the Board of Directors of the Utah Opera Company.

**Jo Brandt** (*Representative of the public*).

Ms. Brandt graduated from South High School and pursued a music degree at the University of Utah. For 25 years she has held leadership roles with the Utah League of Women Voters, having served as its president and later as its executive director. From 1981-83 she served in the Utah House of Representatives representing an area near the (see page 11)

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("Mineral Resources" cont'd. from page 1)

of total mineral value produced by each of the three major segments of the mineral industry in 10-year intervals since 1870 (actual mineral values are not indicated). The exploitation of metallic minerals dominated the industry until recently, when the energy fuels surpassed them in value.

### Metallic Minerals

Utah has always been an important producer of gold, silver, copper, lead, and zinc; the annual production rates of these commodities are shown on Figure 2. Iron has been mined from southwestern Utah.

Utah's metallic mineral industry has declined in recent years because of foreign competition, bad economic conditions, substitutes, and stringent environmental regulations imposed on the smelters or blast furnaces that process the metals. Present production levels of lead, zinc, and iron have reached insignificant proportions. Silver production has gradually declined since the 1920s, and since 1980 the present recession has forced a significant decline in gold and copper production.

### Energy Fuels

A slow but steady increase in mineral fuel values, dominated by coal production, ended at the end of the 1920s, when the country was struck by depression, and more importantly, when petroleum products began to be imported into Utah. In the late 1940s, Utah came into its own as a petroleum and natural gas producing state. Uranium began to be mined shortly thereafter. As the price of petroleum products increased in the early 1970s, the intermountain electrical power generating industry largely returned to coal for fuel. Figure 3 graphically illustrates the production levels of coal, natural gas, and crude oil in recent years. Uranium production has declined drastically since the latter part of the 1970s because of concerns after an accident occurred in a nuclear generating plant.

### Non-Metallic Materials

Even though the total value of non-metallic minerals produced each year re-

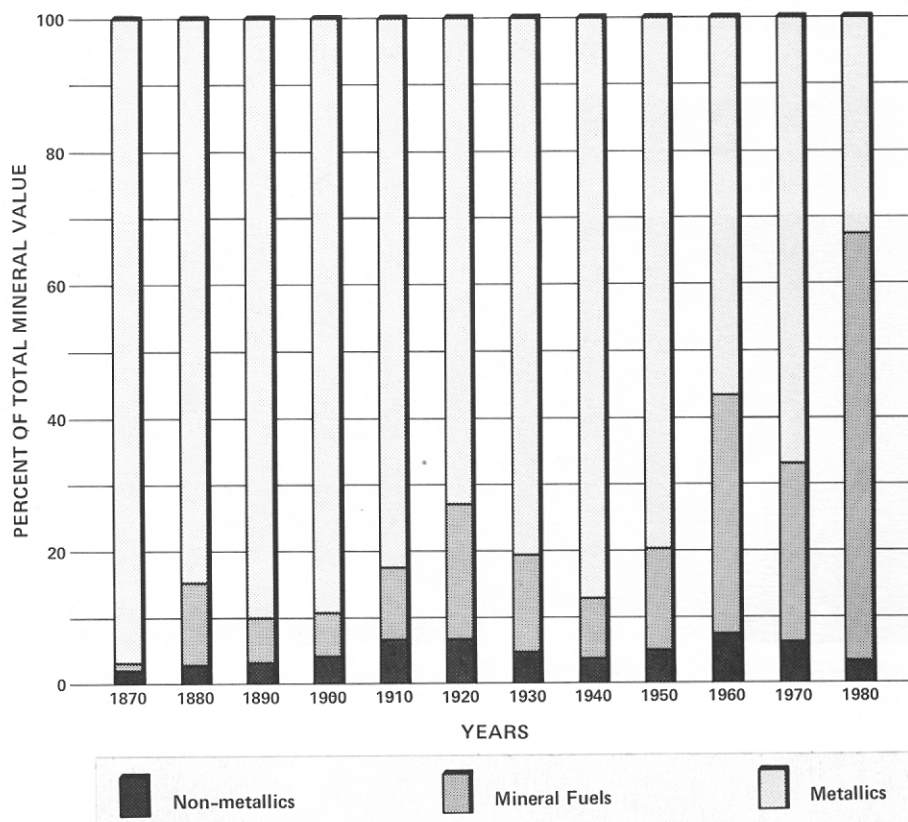


Figure 1. Non-metallics, mineral fuels, and metallics, percentage of total mineral value produced in 10-year intervals in Utah.

mains a small percentage of Utah's total mineral value (Figure 1), its dollar value continues to climb. Production of clays, flourspar, gypsum, lime, pumice, salt and potash, dimension stone, crushed stone, and sand and gravel, is presently valued at 75 to 100 million dollars annually. These minerals are converted to construction materials or used directly as such by construction industries (bricks, cinder blocks, wall board, road-bed material, cement, refractory materials, fill, ornamental and decorative stone, etc.) or by the chemical and fertilizer industries (potash, water softeners, table or animal salt, gypsum, phosphate, fluorine, etc.).

### UTAH MINERAL OCCURRENCES

Exploitable mineral commodities are scattered over the entire state. Few areas have no mineral resources. The mining of these commodities is, of course, controlled by supply and demand, cost of mining, available transportation, and other economic factors. Figures 4, 5, and 6 show the distribution of known resources and it is

reasonable to assume that several additional areas remain to be discovered.

The principal areas of metalliferous mineralization are shown on Figure 4. There are four groupings: Precious and base metals; iron; uranium-vanadium and other radioactive metals; and miscellaneous metals (beryllium, molybdenum, tungsten, antimony, manganese, and others). Because of scale only the more important mineralized areas are shown on the map. Many of the miscellaneous metals are also present in the precious and base metal areas. These areas indicate the most promising prospecting and exploration ground for those commodities. Less than one percent of such areas are underlain with valuable minerals; nevertheless, once discovered, only a few acres of ground can yield millions of dollars worth of metal. Individual areas cannot be compared in any way, especially on the basis of size.

With respect to distribution, it can readily be seen that, except for the uranium-vanadium occurrences, the most favorable metal ground areas are



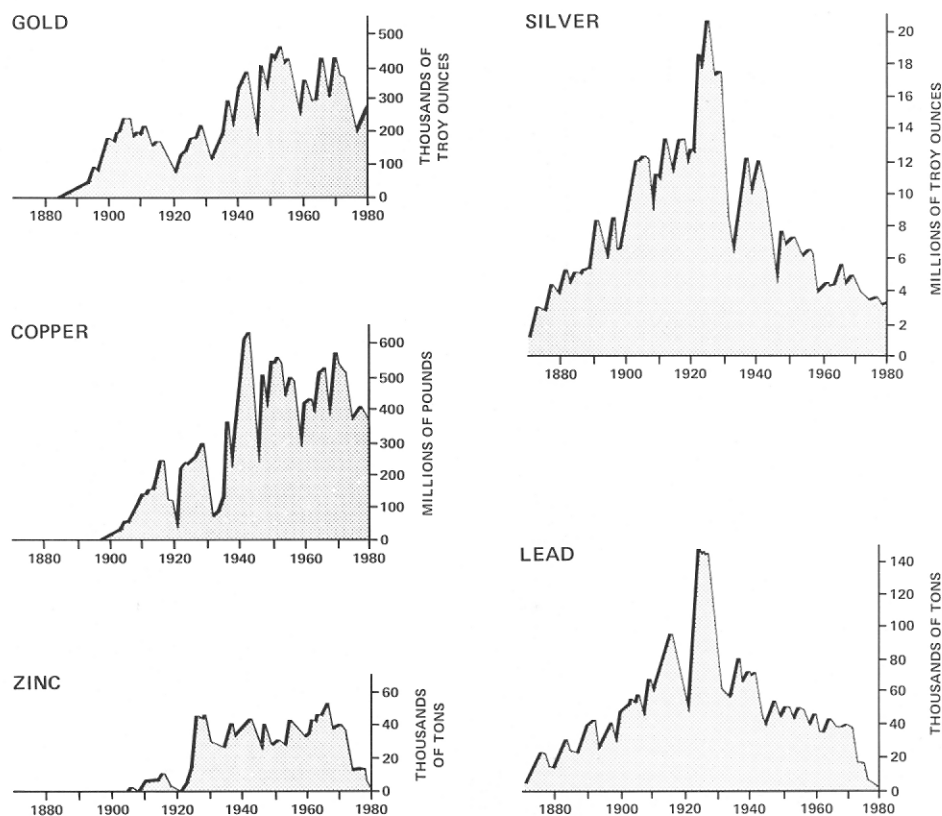


Figure 2. Copper, gold, silver, lead, and zinc production in Utah.

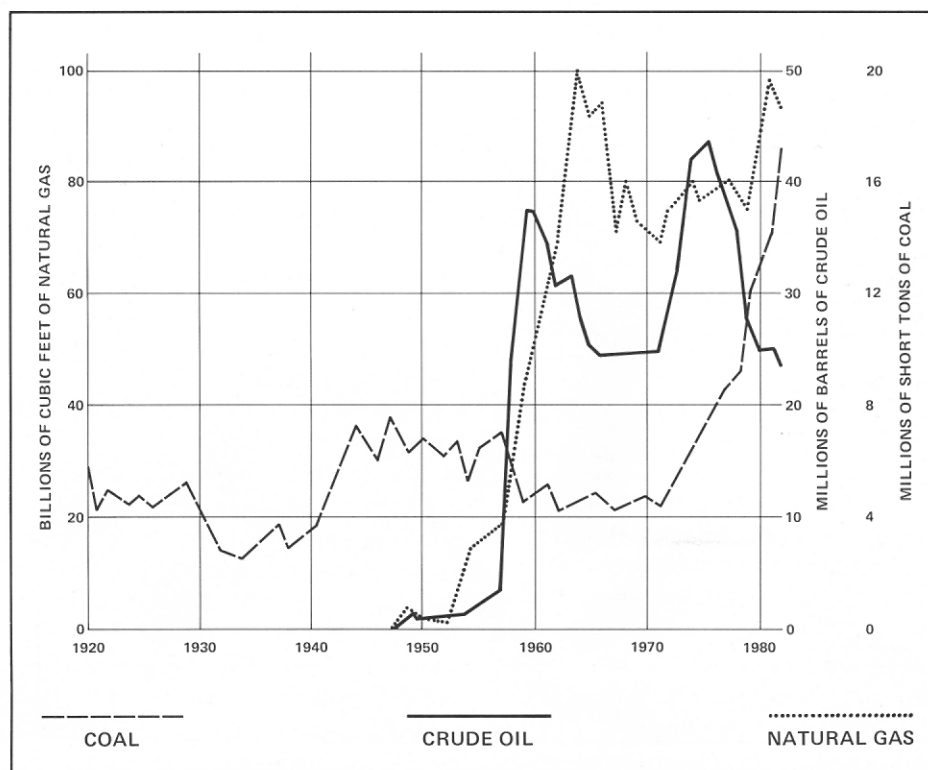


Figure 3. Utah coal, natural gas and crude oil production, 1920-82.

located in the western half of the state. The areas from which the most metals have been produced are concentrated in Beaver, Iron, Juab, Piute, Salt Lake, Summit, Tooele, and Wasatch Counties. Uranium-vanadium mineralization is concentrated in the Colorado Plateau, in the southeastern part of the state, especially in Emery, Garfield, Grand and San Juan Counties. The most discouraging area in the quest for the metallic deposits has been the northeastern part of Utah.

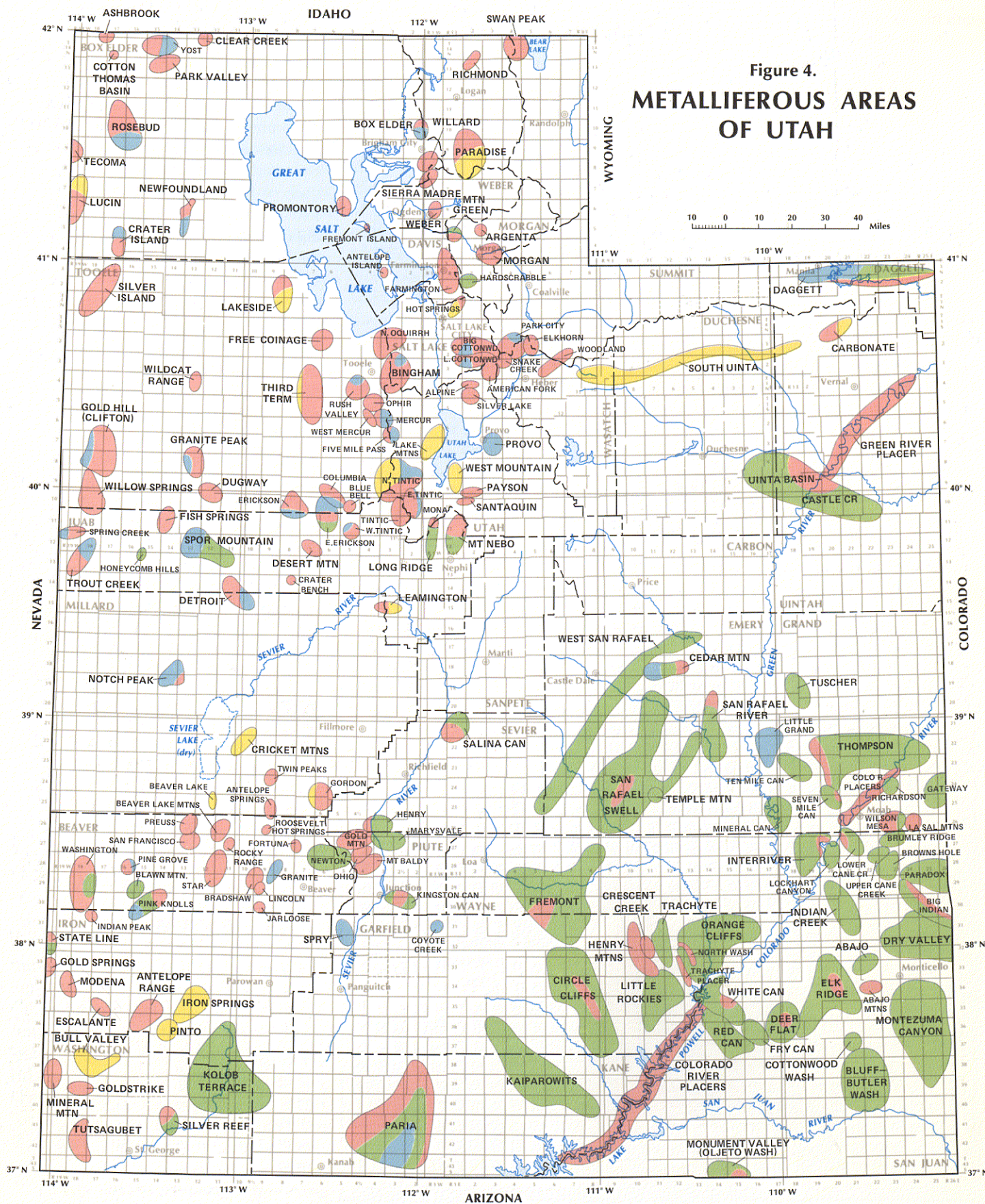
The mineral fuel resources of the state (excepting uranium) are shown on Figure 5. To date, discoveries of these items have been favored in the eastern half of the state, complementing the dominance of metal occurrences in the western half. The petroleum and natural gas fields are especially concentrated in the northcentral, northeastern part and the eastern margin of the state. The more important producers are Summit, Duchesne, Uintah, Grand, and San Juan Counties. Petroleum exploration continues in all parts of the state, indicating that a potential for these fuels exists most everywhere. Tar sand deposits may contain up to 20 percent bituminous materials by weight and Utah's known resources are estimated in the billions of barrels. These resources have scarcely been tapped and await suitable economic conditions. The best known deposits are located in Duchesne, Carbon, Uintah, and Garfield Counties. Oil shale is another great Utah resource potential, principally located in the Uinta Basin (Duchesne and Uintah Counties).

Coal is another important Utah commodity and the best resources are concentrated in central and southwestern Utah (Carbon, Emery, Sevier, Wayne, Garfield, Kane, and Iron Counties). To date, almost all of the coal production has been from the central region. Interesting geothermal resources have also been identified in Utah. These generally parallel the Wasatch Front, being associated with springs issuing from fault zones.

A select grouping of the "industrial", non-metallic resource occurrences are portrayed on Figure 6. In spite of their



Figure 4.  
**METALLIFEROUS AREAS  
OF UTAH**





importance, sand and gravel deposits have been omitted because of their ubiquitous nature in broad areas of the state. Gemstone localities and other miscellaneous commodities have also been omitted from the map. Salines are currently the most valuable non-metallic resource extracted in Utah. Potash and halite are produced from the Great Salt Lake, at the salt flats in Tooele County, at Redmond near the Sanpete-Sevier County line and from the northern Paradox Basin (Grand County). In addition to potash and halite, sodium carbonate, sodium sulfate, magnesium, lithium, bromine, and boron salts have been extracted.

Second in importance, by value, is limestone and dolomite production, used to manufacture cement, lime products, calcium carbide, chemicals, refractories, aggregate, fill, fluxstone, poultry grit, and coal mine rock dust. Limestone and dolomite resources are widespread and the map shows only the developed areas and well-known undeveloped areas. Not all limestone rocks can be used for all purposes; quality and purity are important factors. Tooele, Salt Lake, Weber, Juab, Box Elder, and Cache Counties are among the more important producers.

Sand and gravel production is third in importance to the state. Good deposits are plentiful along the abandoned shorelines of old Lake Bonneville and generally where alluvial materials have been deposited.

Stone production is also an important industry. Utah has abundant resources of all kinds of stone, with many varieties to choose from. Only the presently important areas are mapped. Most stone is used in crushed form (aggregate) for road beds, railroad ballast, concrete aggregate, and riprap. Utah also produces fine dimension and field stones. Especially noteworthy are the Precambrian micaceous quartzites from Box Elder County, the Lower Jurassic salmon-colored Nugget Sandstone of Summit, Salt Lake, Wasatch, and Utah Counties and the Tertiary Bear Valley Sandstone of Garfield and Iron Counties. In the past, granitic and metamorphic rocks were quarried along the Wasatch Front,

especially in Davis and Salt Lake Counties. Volcanic pumice and scoria are mined in and around Washington County for lightweight aggregate and decorative stone.

Gypsum and anhydrite have been identified in many Utah formations, but the best deposits are probably associated with the Jurassic Arapien or Carmel Formations. Large gypsum reserves are also associated with the Pennsylvanian Paradox Formation of southeastern Utah. Gypsite sand dunes are found along the margins of the Great Salt Lake Desert. Utah gypsum resources are among the largest in the United States, but mining is presently limited to Sevier County.

Various types of clays have been, or are being, mined in Utah. Clays are used for a variety of purposes and the use is dictated by chemical properties and purity. Clay is used to make brick, drilling mud, petroleum catalysts, roofing material, reservoir lining, and for decolorizing oils and greases. Clay for brick is mostly mined near the highly populated areas, near the markets, but occasionally a clay that fires into a special popular color is mined in the more remote areas. Clay mining has been, or is, important in Utah, Tooele, Salt Lake, Summit, Weber, Box Elder, and Piute Counties.

Other important non-metallic minerals include the phosphate formations of the Uinta and Wasatch Mountains and the scattered deposits of alunite, barite, fluorspar and sulfur. Gem materials that have been harvested from Utah include obsidian, agate, variscite, petrified wood, topaz, jasper, labradorite, and onyx marble. Important producers have been Juab, Garfield, Millard, Utah, and Box Elder Counties.

#### **HISTORY OF UGMS MINERALS COMMODITIES PROGRAM**

Many territorial governments conducted surveys of their water and mineral resources and these entities later became the states' geological surveys. Utah's geological survey was authorized in 1931 and later funded to inventory Utah's mineral resources in order to promote development. Early survey geologists regularly checked newly reported

mineral occurrences. Later studies systematically reported on petroleum and mineral areas of the state. Today, the economic geology program continues to be the Survey's largest program. It is organized to have experts in the various energy and mineral areas. The present organization is as follows:

#### **UGMS ECONOMIC GEOLOGY PROGRAM AND CURRENT PROJECTS**

##### **Economic Geology Program**

Hellmut H. Doelling - Senior Geologist

##### **Petroleum Section**

Raymond L. Kerns, Section Chief, oil field studies

Karl W. Brown, oil field studies and inventory of resources

Keith Clem, tar sands and oil shales

##### **Energy Section**

Archie D. Smith, Section Chief, coal inventory and petrology

Alex Keith, coal mapping

Robert N. Klauk, geothermal energy

Hasan Mohammad, uranium-vanadium

##### **Mineral Commodities Section**

J. Wallace Gwynn, Section Chief, saline minerals

Paul Sturm, Great Salt Lake research

Bryce T. Tripp, mineral inventory and non-metallic minerals

Harry Messenger III, metallic minerals and mining district studies

**Petroleum Section.** Karl Brown and Keith Clem recently completed a petroleum field data compilation for the Paradox Basin which will soon be published. Karl is now preparing petroleum field data compilations for the Thrust Belt oil and gas fields. Keith Clem is taking a "second look" at the P. R. Spring tar sand deposit for the Division of State Lands and Forestry, measuring new stratigraphic sections of tar sands, taking channel samples and analyzing them to provide an improved resource estimate for the deposit. Similar work is planned for the Sunnyside tar sand deposit.

Ray Kerns recently joined the UGMS staff as the Petroleum Section chief. He plans to undertake oil field studies, reser-



Figure 5.  
ENERGY FUELS  
OF UTAH  
(exclusive of uranium)

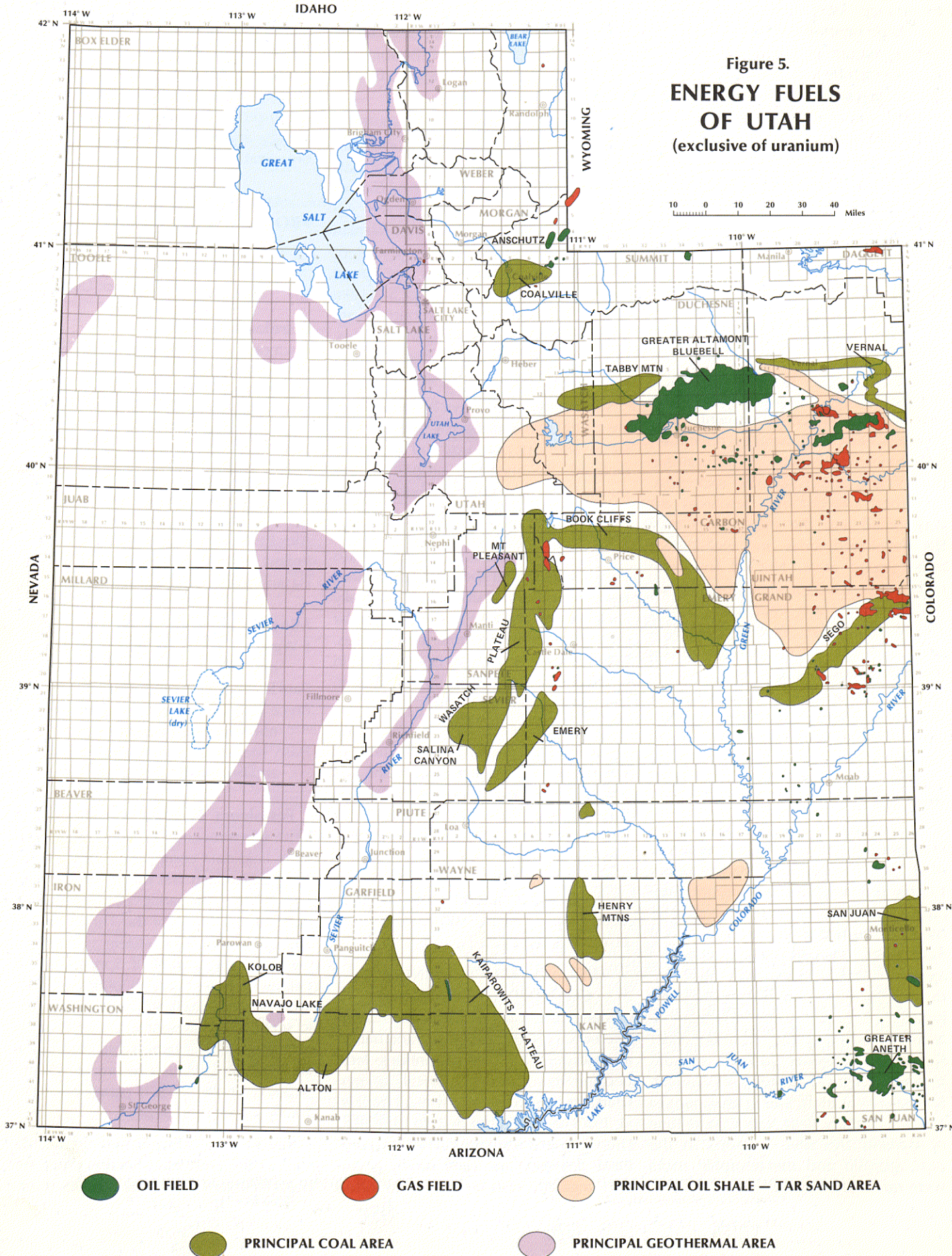
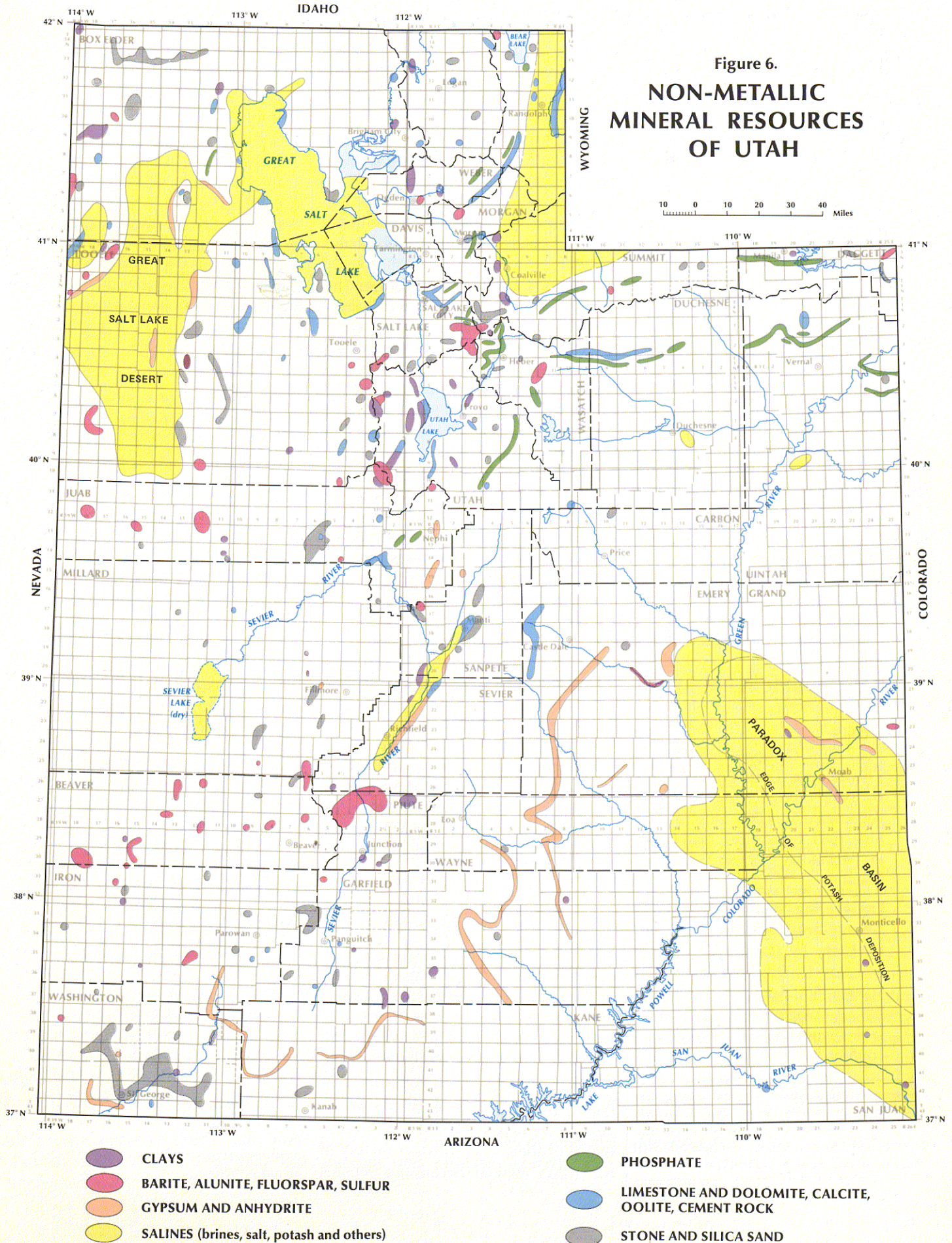




Figure 6.  
NON-METALLIC  
MINERAL RESOURCES  
OF UTAH





voir research, and to prepare an overview of the Thrust Belt. The UGMS sample listing catalogue is being updated to show which oil well samples and geophysical logs are available at UGMS.

**Energy Section.** In the coal research area, several 7.5-minute quadrangles are being mapped, notably in the Book Cliffs, Wasatch Plateau, Sego and Henry Mountains coal fields. The geology, structure, and available coal data are being mapped by graduate students supervised by Archie Smith and Alex Keith. Much raw coal data (coal bed thicknesses, splits, interburden characteristics, overburden characteristics, proximate and ultimate analyses, coal petrology data, production, reserves, coal gas content, site-specific data) are being entered into a computer, later to be used to produce reliable isopach, overburden, interburden, quality, resource, and other types of coal maps.

Robert Klauk has been supervising several graduate students to monitor the principal geothermal areas of Utah. These geothermal assessments will soon appear as UGMS open-file reports, to be

condensed into a bulletin on the "Geothermal Resources of Utah."

Hasan Mohammad has reviewed the geology and resources of the active uranium mines in southeastern Utah and has studied the uranium potential of the Cutler Formation in the area of the proposed nuclear waste repository near Gibson Dome. These reports should be appearing in open-file form in the near future. Hasan will then study the uranium potential of Utah's Great Basin.

**Mineral Commodities Section.** This section has a diverse number of current projects underway ranging from Great Salt Lake research to the studying of the Goldstrike mining district in Washington County. Wally Gwynn has studied the Gibson Dome Paradox Formation salt core and the potential problems that could be encountered in mining the salt during construction of a nuclear waste repository. In addition, he continues his studies of salt pond chemistries (Great Salt Lake) and Sevier Lake sediments. Paul Sturm continues to work on the Great Salt Lake, monitoring and recording temperatures, composition and

other properties of the saline water body. In the future he plans to produce a bibliography of Great Salt Lake research and to prepare sets of maps and reports delineating the data he has faithfully collected through the years.

Bryce Tripp has nearly completed cataloging all of the known mineral occurrences of Utah into the CRIB (Computer Resource Information Bank) system of the U.S. Geological Survey (to date more than 8,000 entries), and has begun updating it (see announcement below on this page). As part of the mineral inventorying program, Bryce is also mapping the tar sand deposits located along the east side of the San Rafael Swell in Emery County.

Harry Messenger is presently studying and mapping the Goldstrike mining district in Washington County and his report is scheduled for completion later this year. ■

*Editor's Note:* Figures 4 and 6 will be available this October (as UGMS Map 70 and 71, respectively), at the scale of 1:750,000, in full-color, and will include locations of mineral occurrences; Figure 5 is now available, in greater detail (1:500,000), as UGMS Map 68.

## NEW PUBLICATIONS

### From UGMS:

- Map 69 - **Geologic map of the Thistle area, Utah County, Utah**, by Irving J. Witkind and William R. Page, scale 1:24,000, 28½" x 31½", June 1983, two-colors; map folded in envelope; \$2.50 over-the-counter.
- **Engineering geology of the St. George area, Washington County, Utah**, by Gary E. Christenson and Roy D. Deen, UGMS Special Studies 58, April 1983, 32 p., 9 figs., 2 color plates (in pocket), 3 tables, appendix; \$7.50 over-the-counter.

**Orders must be pre-paid.** Postage rates: Orders less than \$10.00, add \$1.50; \$10.00 - 24.99, add \$3.00; \$25.00 - \$100.00, add \$5.00; more than \$100.00, add \$10.00; add \$1.50 for tube for rolled map (maximum of four map sheets per tube).

## "CRIB" REPORTS AVAILABLE

Information from the CRIB (Computerized Resources Information Bank) Project, a six year old cooperative project with the Bureau of Land Management and U.S. Geological Survey is now available from the UGMS Sales Office.

CRIB includes site specific data on metallic, industrial and energy mineral localities throughout the state.

The data are available in the form of county reports or custom computer searches. The county reports have been completed for Duchesne, Emery, Grand, San Juan, and Uinta Counties with the remaining counties scheduled for completion by the end of 1983. The charge for a copy of a county printout (Open-file Report) is up to \$30.00. A custom computer search allows the retrieval of specific information on any of the 6,200 mineral occurrence records

currently in the database. Any data from these records can be output in a variety of formats tailored to the individual needs of the user. The charge for a custom search is directly related to the amount of material retrieved. ■

### GREAT SALT LAKE LEVEL

Date (1983)	Boat Harbor	Saline
	South Arm (in feet)	North Arm (in feet)
January 1	4201.65	4199.40
January 15	4201.80	4199.55
February 1	4202.10	4199.85
February 15	4202.35	4200.05
March 1	4202.45	4200.20
March 15	4202.65	4200.40
April 1	4203.20	4200.65
April 15	4203.45	4200.85

Source: USGS Water Resources Division.

Note: The February 15 reading surpassed the most recent high lake level of 4202.25 which occurred in 1976.



## 1981 PEAK MINERAL ACTIVITY YEAR IN UTAH

By **MARTHA RYDER SMITH**

A summary of Utah's mineral activity for 1980, 1981, and 1982 shows that 1981 was a year of peak exploration activity and mineral production in the State. By the end of 1981 and through 1982, Utah's mineral industry suffered as a result of the worldwide recession, increased energy costs, inflation and high interest rates.

Utah's non-fuel metal production in 1981 reached a peak of \$783 million, up from \$764 million in 1980, but fell to \$627 million in 1982. The principal non-fuel metals produced were beryllium, copper, iron, gold, silver, magnesium, and molybdenum.

In early 1981, Kennecott Minerals — the world's largest producer of copper — was purchased by Standard Oil of Ohio (SOHIO). As copper prices dropped from an average of \$1.02 in 1980 to an average of \$.74 in 1982, well below actual cost of production, Kennecott Minerals reduced staff to cut costs, and Anaconda's Carr Fork mine, Utah's second largest producer of copper, was closed.

Gold, silver, molybdenum and other metals are produced largely as by-products of copper mining in Utah, so the production of these metals was also down in 1982. Gold, which had averaged \$612 per ounce in 1980, dropped to \$397 in 1982. Silver dropped from an average of \$20.63 per ounce in 1980 to \$8.00 in 1982. All mines active in 1980 in the Park City (Summit County) and Tintic (Utah County) lode mining districts were closed by the end of 1982.

Iron mining in the Iron Springs (Iron County) district was continuous from 1852 until the last mines were closed in 1982. This closing reflects the recession, as well as competition from overseas steel.

In contrast, Ranchers Exploration and Development Corporation completed its silver mill near Escalante (Iron County) and by the end of 1982 had recovered over 1.6 million ounces of

silver. In Tooele County, Getty Minerals was constructing a 3,000 ton per day mill to produce gold from its open pit mine in the old Mercur (Camp Floyd) mining district. And in Beaver County, Freeport Minerals announced plans to reopen the old Horn Silver mine in the San Francisco district.

Production of oil and gas followed the same general trend as the metals, with crude oil production peaking at 25 million barrels in 1981 and dropping to 22.9 million in 1982. Natural gas production was 98,784 mmcf in 1981 and 94,255 mmcf in 1982. Petroleum exploration activity also dropped in 1982 as a result of falling prices following the oil glut of 1980. The newly developed Anschutz Ranch field in Summit County has not yet gone into production but promises reserves of over a billion barrels of oil.

Coal production rose from a record-breaking 14.2 million tons in 1981 to a surprising 17.6 million tons in 1982, considering that in late 1981 and in 1982 demand declined, especially from the Far East, in response to the drop in oil prices and as Australia and China provided a more attractive source for the Far Eastern countries.

No direct figures are available for values of mineral fuel production, but in 1981 the State collected \$16.3 million in occupation taxes (2%) for oil and gas and \$4.4 million for metal (1%). No occupation tax is collected in Utah for coal or non-metallic minerals.

The uranium industry is still suffering from a severe recession, primarily as a result of public fear of nuclear reactors and also because of foreign competition. High construction costs, high interest rates and severe government restrictions have made the nuclear power less competitive with oil and coal as a source of electrical power.

Utah has large reserves of industrial minerals and produces cement, clay, (see page 16)

("Meet the Members" cont'd. from page 3)

University of Utah. She served on the legislative Energy and Natural Resources Committee and played an active role in water issues, solar energy, and community development. She has also been the owner of an insurance salvage company, the executive director of Western Survey Research, and presently is a paralegal with Sessions and Moore.

**James H. Gardner** (*College of Business at the University of Utah*).

Dr. Gardner earned his bachelor's degree in chemical engineering from the University of Utah and a master's and Ph.D. degree in chemistry from Harvard University. His professional experience includes positions with Shell Oil Company, National Research Corporation, U.S. Department of Defense, and president of ArmaK Company and includes research, engineering, business development, general management and policy development. In 1975, he joined the University of Utah faculty and served as dean of the Graduate School of Business from September 1980 through June 1983.

**E. Peter Matthies** (*Vice President and General Manager, Sharon Steel Mining Division*).

After Mr. Matthies graduated from high school in West Germany, he worked for 4-1/2 years in coal mines in his homeland while earning his master's degree in petroleum and mining engineering from the Technical College in Aachen, West Germany. Following his arrival in the United States, in 1958, he worked as a roughneck in West Texas. He then joined Union Oil Company as a petroleum engineer, became district production superintendent, and later advanced to manager of operations in Indonesia and Bolivia. In 1975, he joined Northwest Energy Company as manager of operations for international ventures; in 1978 he assumed the responsibility of managing Northwest Coal Company. He joined Sharon Steel in August 1981 and oversees their Alaskan Gold Company, U.S. Fuel Company, Utah Railway Company, Continental Mine New Mexico, U.S. Lead Company, and various other subsidiaries.

(see page 15)

# LOOKING BACKWARD

By Wm. LEE STOKES

## Elucidating the Uinta Range

Even though the Ogden Quartzite of King's 40th Parallel Survey later turned out to be a slice of Cambrian thrust out of place into a higher position, there was a time when geologists generally felt obliged to find it in nearby sections. Weeks, for example, looked for and found it in the Uintas (Geological Society of America Bulletin, 1907, v. 18, p. 427-448). To him the Uinta Mountain Group was the basal clastic unit, the Red Pine Shale was equivalent to the Utah Formation of King, and what to him was the Ogden later became the Tintic or Brigham. The

## Looking Backward

Second article in a continuing series

realization that the Red Pine is Precambrian and not Cambrian was not established until the 1970s.

Weeks' contribution takes us to the Uinta Range. Three of the four great pioneer geological surveys of the West entered these mountains in the period from 1865 to 1875. All were concerned with dating the immense body of quartzite, indurated sandstone, and shale that make up the core of the range. Fossils were very much needed and eventually were found. Let King himself describe the initial discovery:

"Upon the slopes of Mt. Agassiz, about 1000 to 1500 feet below the summit, in a piece of quartzite debris which could not be distinguished from the rocks *in situ* immediately above it, was obtained half a ribbed brachiopod, referred with some doubt by Hall and Whitfield to *Spirifer imbrex*. The material of the fossil itself is precisely that of the enclosing quartzite, and there is a strong possibility that the fragment represents a horizon 700 feet down from the summit of Mt. Agassiz, and the fossil, which is a Carboniferous one, offers very fair evidence of the age of the series. It is altogether impossible that a fragment of the limestone, which once

arched over the region could have withstood the long period of erosion, which has degraded the range since the close of the Cretaceous age. I therefore conclude that this cannot be a relic of the fossiliferous upper Coal Measures which were once vertically above the spot. It seems equally improbable that a traveler, Indian or otherwise, should have accidentally dropped on this debris pile a foreign fragment identical with the neighboring rock in place." (King, C., *Systematic Geology: U.S. Geological Exploration of the Fortieth Parallel*, vol. 1, p. 152-153).

Never has so much importance been attached to a single fossil, in this case half of one. King put forth some good arguments that this specimen was de-

rived from nearby outcrops but we know now that this cannot be. How it got there remains unexplained. I can only wish that someone had searched the pockets of the entire crew before they took this particular route. Could it be that a packer, cook, or guide wanted to help the boss and put an end to his complaints about no fossils?

Thus on the basis of little more than *Spirifer imbrex* King assigned a Carboniferous age to the Uinta Mountain Group. This was followed by other guesses. It was called Devonian on the basis that there was too much Carboniferous and some of the excess must belong to the preceeding period. Without explanation it is shown as Late Proterozoic on the first geologic map of North America and, again without cited evidence, to the Cambrian in U.S. Geological Survey Professional Paper III which included the first geologic map of Utah. It was also designated Silurian by



Figure 1. Mt. Agassiz, Uinta Range, Utah. From a photograph taken in 1871 and used as an illustration for Clarence King's report on his explorations of the 40th Parallel.



O. C. Marsh at a time when the Ordovician was not a recognized period in North America. Things began to stabilize when the Uinta core was shown as Precambrian undifferentiated on the 1948 U.S. Geological Survey map of eastern Utah. In 1975, a specific assignment of the Red Pine Shale to Precambrian was made on the basis of a radiometric date (Crittenden and Peterman, *Utah Geology*, 1975, v. 2, no. 1, p. 75-77).

We now know that the Uinta Mountain Group is at least 25,000 feet thick and that there are at least 12,000 feet of Precambrian rocks younger than are in the State of Utah. It is fortunate that the earlier geologists did not know these disturbing facts.

The required fossil evidence was very slow in coming. Authentic Late Cambrian fossils were found by the Untermanns in the Lodore Formation in 1945 and in the early 1950s N. C. Williams reported Cambrian brachiopods from the western equivalent of the Lodore - that is, from Weeks' Ogden or present day Tintic or Brigham. In 1977, the middle Precambrian microfossil *Chuarina* was reported from the Red Pine Shale (the Utah Formation of Weeks and the Ophir of many subsequent geologists). Where

were those vaunted Cambrian guide fossils, the trilobites, hiding when we needed them so much?

As to the structure of the Uinta Range, a similar history of change in thinking is evident. One of the most-used textbook illustrations on Utah geology is Powell's cross-section of the Uinta Range intended to illustrate the anticlinal structure and the thickness of strata removed to expose the core. There is one displacement, the North Flank fault, to break the general anticlinal symmetry. King's Atlas also shows a part of the North Flank fault.

With passage of time, the Crestal fault and the South Flank fault were discovered. According to a sort of unwritten rule of early geologic cartography, all faults with unknown inclinations, were to be drawn vertically, and thus the North Flank fault is shown by Powell. All Uinta faults are shown as high-angle normal by Forrester as late as 1937 (Geological Society of America Bulletin, 1937, v. 48, p. 631-666). According to this the Uinta Range is a simple horst.

Still later, mostly on geophysical evidence, the flanking faults were found to incline steeply downward under the

range. Radical thinkers convinced us that the northwestern segment of the mountains was thrust upon the Green River Basin. This shocking fact was proven by drilling through Precambrian into a recognizable Mesozoic section below. Interpretations of the South Flank fault are similar and the Uinta arch must be drawn with a mushroom shaped cross-section, perhaps totally extruded and underthrust from both north and south.

As concepts of Uinta structure have changed, so have ideas of fundamental tectonics. The sediments of the Uinta Mountain Series have been referred to as having originated in a trough, in a basin, and in a geosyncline. The sediments as such have been referred to as a pod, as a prism, and as a geosyncline. But with plate tectonics came the concept of the aulacogen and it may be both accurate and genetically descriptive to refer to the Uinta trough as an aulacogen or as the "failed arm of a triple junction." No one seems to have marshalled all the evidence so as to give veracity to the idea, but the term Uinta Aulacogen is slowly finding a place in geologic literature. Apparently, under this theory the distribution of forces during the Laramide was such that the opposing walls or faces of the aulacogen were forced toward each other to extrude the Uinta Range. Yet to be elucidated is the 1500 million year history of the aulacogen between the final filling and the Paleocene uplift. As aulacogens are becoming better known, it is evident that contents may rise or sink as tension or compression dictates. Thus the Uinta block may have moved upward on occasion to produce a thin overlying section or downward to produce a thick one. The history of thought may be indicated by the types of faults we have drawn; thus, at first, no faults, then simple normal, near-vertical faults, then steep thrust faults, then low-angle thrusts passing into high-angle thrusts and finally faults with double-headed arrows indicating alternating directions of movement on the same planes. Someone needs to determine whether the last movement on the Uinta flanking faults elevated or depressed the core.



Figure 2. A critical fragment. This broken half-brachiopod, identified as *Spirifer imbrex*, is the basis on which Clarence King dated the central quartzite core of the Uinta Mountains as Carboniferous. Later work showed the age to be Precambrian.

## Utah Earthquake Activity — October 1982 to March 1983

By WILLIAM D. RICHINS<sup>1</sup>

The University of Utah Seismograph Stations records a 60-station seismic network designed for local earthquake monitoring within Utah, southeastern Idaho, and western Wyoming. This report provides a summary of earthquake activity in the Utah region for the two quarters; October-December, 1982 and January-March, 1983 (Figure 1 and 2).

In this report, the northern boundary of a rectangular area designated "the Utah region" (for purposes of earthquake summaries) has been extended northward by 10 minutes of latitude to 42°40'N. This was done to include significant earthquake activity near Soda Springs, Idaho, less than 50 miles from

Utah's northern border.

During October to December 1982, 451 earthquakes were located within the Utah region; 159 were located in this same area during January to March 1983. The largest earthquake during the 6-month period of this report was a magnitude 4.7 shock 12 km southeast of Soda Springs, Idaho. This event was widely felt in the Soda Springs area and was part of an earthquake swarm sequence which began in December 1981. At least 55 earthquakes were felt during October 1982 at the Lakey Ranch, approximately 10 km southeast of Soda Springs. A detailed report on this swarm sequence is in preparation (for preliminary details, see Richins, W. D., W. J. Arabasz and C. J. Langer, 1983, Episodic Earthquake Swarms [ML 4.7] near Soda Springs, Idaho, 1981-82: Correlation

with Local Structure and Regional Tectonics, abstract, *Earthquake Notes* 54 no. 1). Other significant aspects of earthquake activity shown in Figures 1 and 2 include (north-south):

- (1) a magnitude 3.3 earthquake near Malad City, Idaho on December 24, 1982, which was felt in Malad City and nearby communities;
- (2) on-going microseismicity with magnitudes less than 2.0 50-75 km west of Logan within Hansel Valley, Pocatello Valley and surrounding areas;
- (3) continued activity with magnitudes less than 1.6 east of Logan beneath the Bear River Range;
- (4) a magnitude 2.8 earthquake approximately 20 km southeast of Ogden on March 6, 1983, which

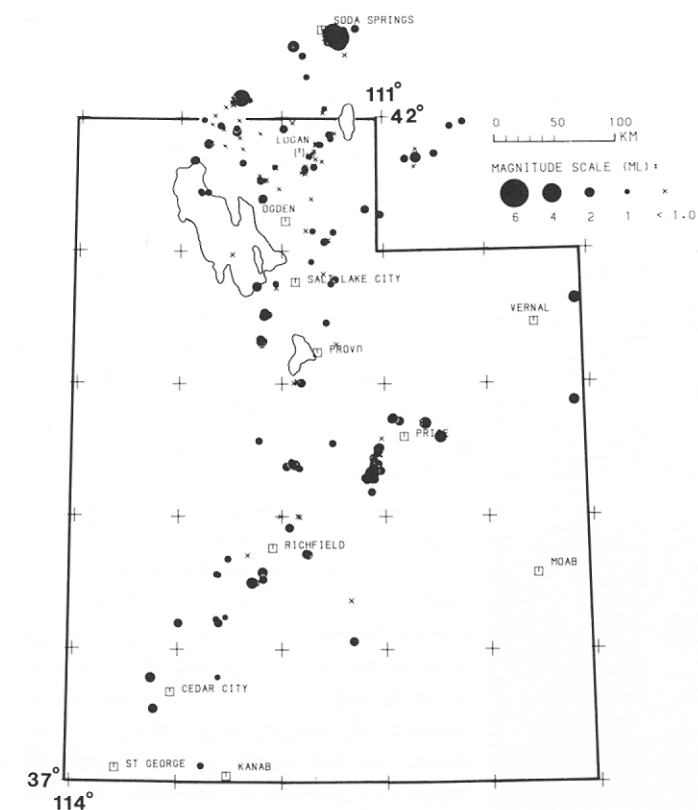


Figure 1. Utah earthquakes, October - December 1982.

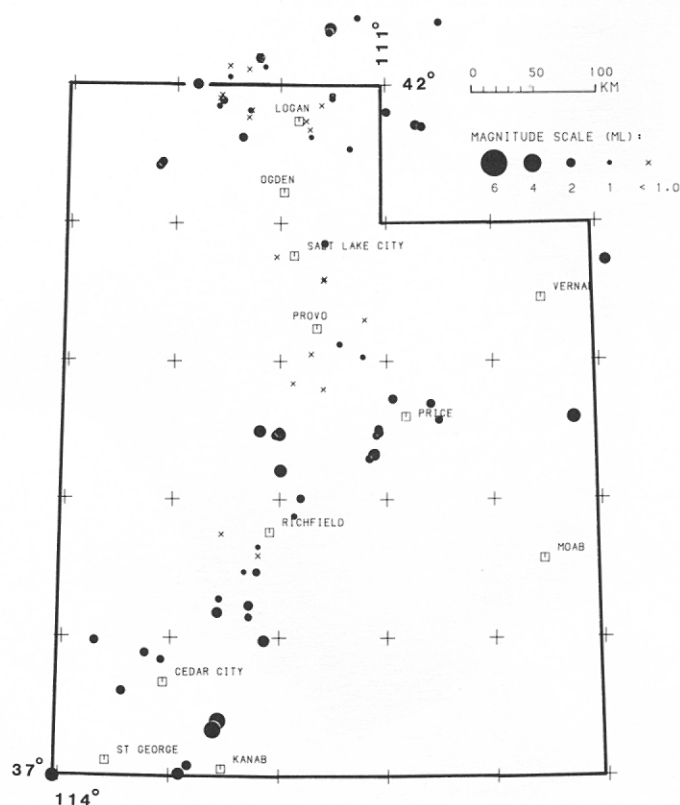


Figure 2. Utah earthquakes, January - March 1983.

<sup>1</sup>Senior staff seismologist, University of Utah Seismograph Stations.



("Meet the Members" cont'd. from page 11)

**Elliot Rich** (*Associate Dean, College of Engineering, Utah State University*).

Dr. Rich earned his bachelors degree in civil engineering from Utah State University, masters at the University of Utah, and doctorate from the University of Colorado. He worked as an hydraulics engineer for the U.S. Bureau of Reclamation. He began his teaching career at Weber State College where he later served as the head of the Department of Engineering. In 1967, he moved to Logan as associate professor of civil engineering. He is presently professor of Civil and Environmental Engineering at Utah State University.

**Robert W. Bernick** (*Vice President, First Interstate Bank of Utah, N.A.*), *Retiring from UGMS Board.*

Mr. Bernick earned his bachelor's degree in journalism from the University of Missouri. He worked variously as a reporter and editor for The Associated Press, the United Press International, Salt Lake Telegram, and The Salt Lake Tribune. He was business and mining

editor for the Tribune and was regional correspondent for McGraw Hill World News (Engineering and Mining Journal; Chemical Week Magazine; Platt Oilgram; Coal Age; and Engineering News Record, etc.). He also served as an industrial engineer for Nevada Mines Division, Kennecott Corporation.

Mr. Bernick has served on many community and professional boards including the Utah Mining Association, Utah Petroleum Association, Utah Manufacturers Association, AIME/SPE, Rocky Mountain Coal Mining Institute, Independent Petroleum Association, American Mining Congress. He is a member and representative in the Basin and Range Geothermal Resources Council and is on the advisory board of the College of Mines and Mineral Industries of the University of Utah.

**Benton Boyd** (*U.S. Fuel Company, retired*), *Retiring from UGMS Board.*

Mr. Boyd earned his bachelor's degree in mining engineering from The Pennsylvania State University. After mine work in Grass Valley, California,

and Boise Basin, Idaho, he was employed in 1937 as a mucker at the U.S. and Lark Mine of United States Smelting, Refining and Mining Company (now UV Industries, Inc.), and later worked as engineer, foreman, superintendent, and then as manager. In 1962, he was named vice president and general manager of western operations of the company and president of United States Fuel Company. He has been an active member of AIME, past president of the Utah Mining Association, chairman of the Board of Governors Western Division of the American Mining Congress, and member of the advisory council of the College of Mines and Mineral Industries at the University of Utah.

**Natalie R. Mallinckrodt** (*Representative of the public*), *Retiring from UGMS Board.*

Mrs. Mallinckrodt earned her bachelor's degree from Mount Holyoke and master's degree in history and political science from Columbia University. She then taught history, economics, and (see page 16)

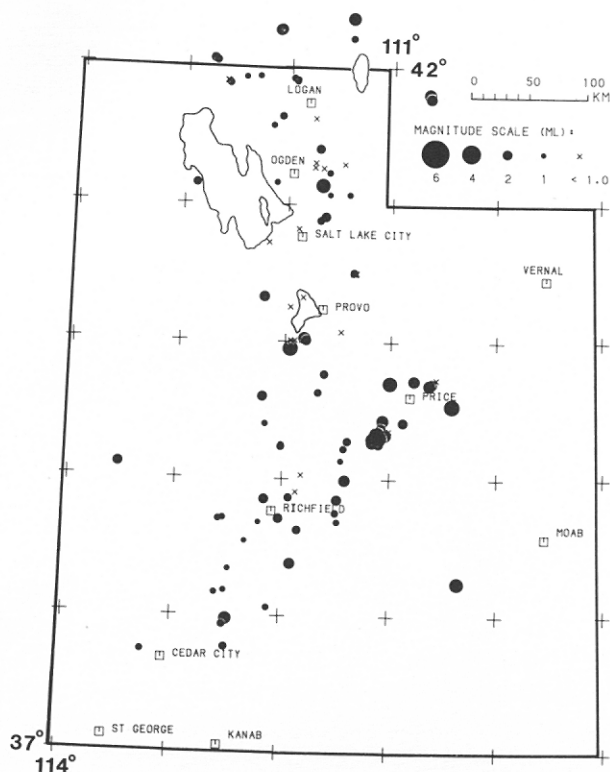


Figure 3. Utah earthquakes, 1982.

was felt in Mountain Green, Ogden, Morgan and other nearby communities;

- (5) a magnitude 2.6 earthquake south of Utah Lake within Goshen Valley on January 22, 1983;
- (6) activity with magnitudes less than 2.0 near the southern end of the Wasatch fault zone about 40 km north of Richfield; and
- (7) continued activity in the vicinity of active coal mining, north and southwest of Price, including a felt event of magnitude 3.1 on March 22, 1983 near Sunnyside.

During 1982, 875 earthquakes were located within the Utah region (Figure 3). Quarterly details are available in this and previous issues of *Survey Notes*. Additional information on earthquake data within Utah is available by contacting the University of Utah Seismograph Stations, Salt Lake City, UT 84112. ■

("Meet the Members" cont'd. from page 15)

government at the high school level in New York City. She has served as chairman and as a member of many state and county community committees. In particular, she has served as an officer and a committee chairman for the League of Women Voters, American Association of University Women, Women's State Legislative Council, Community Services Council, United Fund, and Women's Auxiliary of the American Institute of Mining, Metallurgical and Petroleum Engineers. ■

("1981 Peak" cont'd. from page 11)

crushed stone, sand and gravel, gypsum, lime and limestone. Phosphate and gilsonite are mined in the eastern Uinta Basin. Potash is mined from buried salt deposits near Moab (Grand County).

Magnesium metal and a variety of salts are recovered from the brine of Great Salt Lake. The unusually high precipitation of 1982-83, and the consequent rise in the level of the Great Salt Lake, has severely reduced production of salt by diluting the brines and damaging evaporation ponds. ■

## UGMS STAFF CHANGES

Since the last issue of *Survey Notes* the following personnel changes have taken place:

**Sandra Stewart**, illustrator with UGMS since 1978, resigned last December after giving birth to a boy. **Donald E. Powers**, also an illustrator, retired on June 8. Don had worked for UGMS since 1978. **Trena L. Foster**, composer operator in the editorial department, resigned from UGMS on May 6 to pursue a new career. We wish Sandy, Don and Trena all the best in their future endeavors.

Filling the cartography vacancies are **Kent D. Brown** and **Jessie S. Roy** who come to UGMS with a broad mapping background from private industry. **Linda A. Sapienza** is a graphic artist and fills the composer operator position on a half-time basis. We are pleased to have these folks on board. ■

## Great Expectations

During 1983 the USGS, through its National Mapping Program, expects to sell and distribute more than 9 million copies of its nearly 67,000 published topographic maps. ■

## REMINDER

The Governor's Conference on Geologic Hazards will be held August 11-12, 1983 at the University of Utah campus in Salt Lake City (for details see flyer in the last issue of *Survey Notes* or contact Angela Harwood, Conference Coordinator at Utah Geological and Mineral Survey, 606 Black Hawk Way, Salt Lake City, UT 84108-1280, 581-6831).

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